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## *Brief communication*

# “Hurricane Irene: a wake-up call for New York City?”

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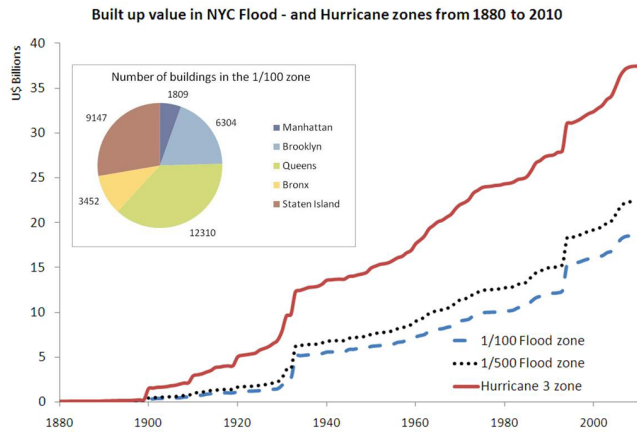
**Abstract.** The weakening of Irene from a Category 3 hurricane to a tropical storm resulted in less damage in New York City (NYC) than initially was anticipated. It is widely recognized that the storm surge and associated flooding could have been much more severe. In a recent study, we showed that a direct hit to the city from a hurricane may expose an enormous number of people to flooding. A major hurricane has the potential to cause large-scale damage in NYC. The city’s resilience to flooding can be increased by improving and integrating flood insurance, flood zoning, and building code policies.

## 1 Introduction

Hurricane Irene has revealed the inconvenient truth to New Yorkers that they are populating an area that is vulnerable to coastal flooding by major hurricanes. Irene has raised a discussion about how vulnerable NYC is to major hurricanes, and about whether the evacuations coordinated by Mayor Bloomberg were necessary. Despite the weakening of Hurricane Irene to a tropical storm when it made landfall on Long Island, water levels in Lower Manhattan still increased to an inch below the most recent damaging storm, i.e. that of December 1992. Hurricane Irene draws attention to existing studies showing that NYC is one of the world’s most vulnerable cities to coastal flooding (Nicholls et al., 2003). In addition, historical flood events have shown that hurricanes and winter storms (“nor’easters”) can have considerable impacts on the city. NYC has been struck by 15 hurricanes since the year 1815, with a maximum strength of Category 3 on the Saphir-Simpson scale (Gornitz et al., 2001). The 1938 hurricane, “Long Island Express”, is ranked as the sixth-worst hurricane in US history and caused ~US\$ 38 bn damage (in

US\$ 2008 values) to the NY region (Pielke et al., 2008). Flood risks are expected to increase in the future, and a report of the NYC Panel on Climate change shows that sea level rise is expected to increase the frequency of coastal flooding in NYC and enlarge the potential flood zones (NPCC, 2010). Climate Change projections indicate that the zone that is currently expected to flood, on average, each 100 yr (the 1/100 flood zone), may flood approximately four times as frequently by 2080 (Horton et al., 2010). In addition, socio-economic developments, such as population and economic growth, will likely increase the potential consequences of flooding. NYC’s population is projected to continue to grow from over 8.2 mln in 2006 to 9.1 mln in 2030 (NYC-DCP, 2006).

A recent study examined the exposure of NYC to flooding and how flood insurance, flood zoning, and building code policies can limit flood risk (Aerts and Botzen, 2011, 2012). Although the focus of this study is on direct flood risks, it should be noted that other important kind of damages can be caused by hurricanes, such as wind damage and business interruption. About 300 000 people currently live in the 1/100 flood zone. This is roughly the number of evacuees for which mayor Bloomberg had ordered mandatory evacuation. More than 33 000 buildings, representing a value of US\$ 18.3 bn, are located in the same 1/100 flood zone (Fig. 1), of which 252 properties are classified as vital infrastructures, such as schools, power plants, police stations, and airports. The evacuation plans that were implemented shortly before the arrival of Irene prioritized evacuating vital infrastructures such as police stations and elderly housing. In addition, large parts of the Manhattan business district and subway systems are located in vulnerable flood zones, and the impacts of historical floods demonstrate that NYC rail systems are susceptible to flood damage (USACE, 1995). The NYC subway was



**Fig. 1.** Cumulative values of the properties at risk in the 1/100, 1/500, and Hurricane 3 flood zones over time (period 1880–2010, all in net present 2009 values, in US\$ bn). Inset: number of buildings in the 1/100 flood zone, distributed per NYC Borough.

shut down for several days in the wake of Hurricane Irene. Moreover, the potential indirect flood damage to the NYC economy is estimated to be much higher than the value of buildings at risk, since millions of inhabitants may not be able to reach their offices for up to a few weeks, should a major flood strike NYC (Aerts and Botzen, 2011). Even the relatively minor Hurricane Irene resulted in the temporary closure of shops as a result of the mandatory evacuations, which caused severe business interruption damage. No casualties were caused by Irene, which may have been the result of the timely evacuations.

## 2 Flood insurance and urban development

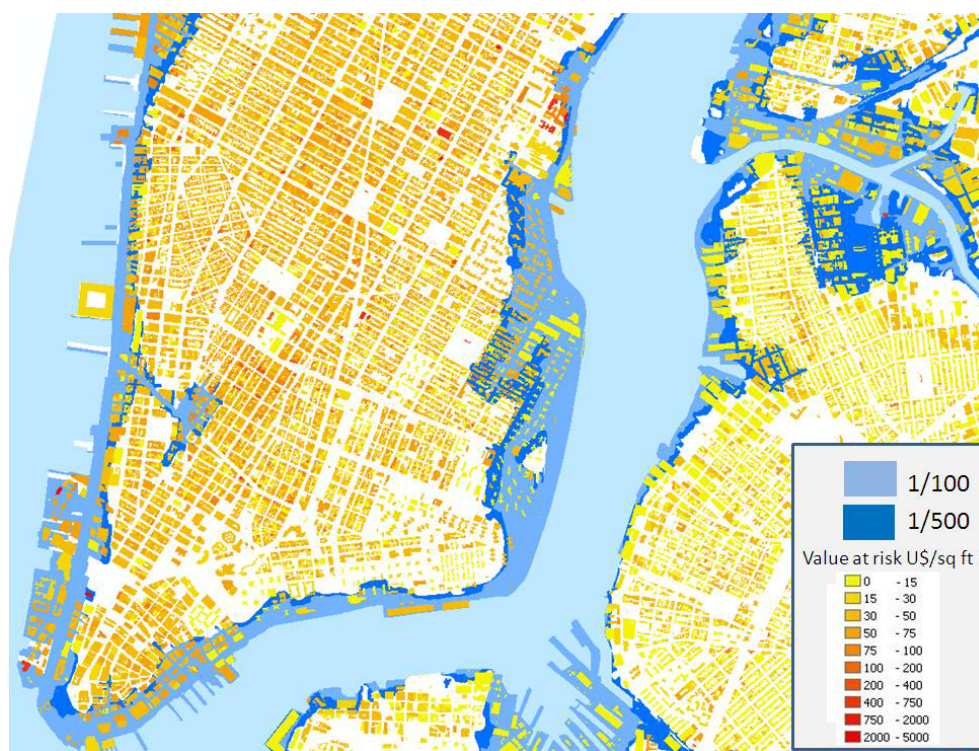
In the US, the federal government provides flood insurance through the National Flood Insurance Program (NFIP), which insures a value of about US\$ 8 bn in NYC. The NFIP is an important program for achieving risk reduction because it imposes the minimum requirements for local government flood zoning and flood building codes in the 1/100 yr flood zone. For example, the NFIP requires that new structures should be elevated to the expected water level of the 1/100 yr flood. The Federal Emergency Management Agency (FEMA) administers the program, sets flood insurance premiums, and sets minimum building standards for properties in the 1/100 flood zone. The NFIP has been relatively successful in limiting the vulnerability of new constructions through flood-proofing measures in the 1/100 flood zone (Burby, 2006). Nevertheless, the historical increase in the number of properties in the NYC flood zone (Fig. 1) shows that the program – launched in 1968 – has been ineffective in limiting new developments in high-risk areas. Moreover, the focus of the NFIP on the 1/100 flood zone is restrictive: many buildings that are exposed to flooding are located in

flood zones with a lower flood probability, where the flood insurance is not compulsory, and minimum elevation requirements do not apply (Figs. 1 and 2). For example, the value at risk in the hurricane 3 zone in NYC, which has a lower probability of flooding than 1/100, is currently estimated at US\$ 34 bn compared with US\$ 18.3bn in the 1/100 yr flood zone (Fig. 1). Moreover, research has shown that elevation above the NFIP requirements can be cost-effective (Jones et al., 2006).

## 3 Fine-tuning federal, state, and city policies

NYC could consider the implementation of additional flood zoning and building code policies that go beyond the minimum NFIP standards and improve protection of the city against flooding. A first step towards regulations that better address flood risk is to improve inter-governmental regulations that are currently not well integrated. For example, NYC building code policy requires “freeboard” (building above the 1/100 flood level) of up to 2 or 3 ft for new structures in the 1/100 flood zone that represent a substantial hazard to human life in the event of failure or for essential facilities (such as hospitals). However, no freeboard is required for residential buildings, although this is advised by both the American Society for Civil Engineers ASCE 24 standard (+1 ft) and the New York State (NYS) building codes (+2 ft) (11). This implies that many residential buildings in the 1/100 flood zone are currently insufficiently protected from floodwaters. It has been demonstrated that investing in (additional) freeboard can be cost-effective in terms of the reduced risk it delivers (Jones et al., 2006). However, current zoning regulations discourage voluntary freeboard, as elevated buildings near the waterfront are subject to zoning height penalties (Sussman and Major, 2010). This penalty arises because zoning height limits prohibit buildings from increasing their elevation above a maximum height. This has the effect that elevated buildings at the waterfront cannot be built or are subject to penalties if they are higher than current regulations. A logical next step would be to eliminate this zoning penalty in case of flood proofing or freeboard measures, and to require freeboard for residential buildings in NYC that are vulnerable to flooding.

Furthermore, climate change and other future developments, such as urban development, are not addressed in the NFIP buildings standards or in FEMA flood maps, on which the NYC building codes are based. As a consequence, many existing and new buildings will be unprepared for future flooding conditions. We therefore advise that insurance and building code regulations should be applied to what is expected to be the future 1/100 flood zone in the life time of a building. A challenge with such a policy change is that this would require the creation of future (forward-looking) flood maps. Moreover, zoning controls can be applied to limit potential flood damage, such as increasing the required “Open



**Fig. 2.** Value at risk in US\$ per square ft based on the ground floor of buildings in Manhattan and Brooklyn (increasing from yellow to red). Note: the map shows in light blue those areas that are expected to be flooded during a 1/100 storm surge, and in dark blue those areas expected to be flooded during a 1/500 flood zone.

Space Ratio". More open space implies a lower building footprint on a building lot, and hence lower potential flood damage (Aerts and Botzen, 2011).

#### 4 Conclusion: a wake-up call for innovative developments?

Vulnerable waterfronts are attractive areas for many uses in NYC, and it is expected that in the coming 20–30 yr, NYC's 1 million new inhabitants will occupy parts of the waterfronts that will be newly developed. Waterfronts are increasingly seen as "multifunctional locations" for economic, environmental, and social activities at the interface between land and water (Jha et al., 2012; Nicholls and Cazenave, 2010). This is a global trend, and many other global coastal cities are facing the same challenge of increasing flood risk (Rosenzweig et al., 2010).

Mayor Bloomberg recently launched Vision 2020, which can provide an attractive perspective on multifunctional waterfronts, as it stimulates innovative strategies that both decrease flood vulnerability, increase environmental values, and increase recreational values for NYC's inhabitants. Such waterfronts can be attractive for residents, provide protection, and serve ecological functions. Examples are already found in other global cities, such as Rotterdam (the Nether-

lands) and Hamburg (Germany) (Aerts et al., 2009). Hurricane Irene may provide a momentum for emphasizing NYC's waterfront as an important line of flood defense in Vision 2020. As such, Hurricane Irene is a wake-up call for the need for innovative solutions to flood protection in NYC, and for implementing additional measures that protect the city from future flood risk and climate change. Priority is needed for the enhanced fine-tuning of protection insurance, zoning and building code regulations.

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#### References

- Aerts, J. C. J. H. and Botzen, W. J. W.: Flood-resilient waterfront development in New York City: Bridging flood insurance, building codes and flood zoning, *Ann. N. Y. Acad. Sci.*, 1227, 1–82, 2011.
- Aerts, J. C. J. H. and Botzen, W. J. W.: Managing Exposure to flooding in New York City (NYC), *Nature Clim. Ch.*, in press, 2012.

- Aerts, J. C. J. H., Major, D., Bowman, M., and Dircke, P.: Connecting Delta Cities: Coastal Cities, Flood Risk Management and Adaptation to Climate Change, VU University Press, Amsterdam, 2009.
- ASCE: Flood resistant design and construction. ASCE/SEI 24-05, The American Society of Civil Engineers (ASCE), Virginia, 2005.
- Burby, R. J.: Hurricane Katrina and the paradoxes of government disaster policy: Bringing about wise governmental decisions for hazardous areas, *Ann. Am. Acad. Pol. Soc. Sci.*, 604, 171–191, 2006.
- Gornitz, V., Couch, S., and Hartig, E. K.: Impacts of sea level rise in New York City metropolitan area, *Global Planet. Change*, 32, 61–88, 2001.
- Horton, R., Gornitz, V., Bowman, M., and Blake, R.: Chapter 3: Climate observations and projections, *Ann. N.Y. Acad. Sci.*, Special Issue New York City Panel on Climate Change, 1196, 41–62, 2010.
- Jha, A. K., Bloch, R., and Lamond, J.: Cities and Flooding: A Guide to Integrated Urban Flood Risk Management for the 21st Century, World Bank, Washington DC, 2012.
- Jones, C. P., Coulborne, W. L., Marshall, J., and Rogers, S. M.: Evaluation of the National Flood Insurance Program's building standards, American Institutes for Research, Washington DC, 2006.
- Nicholls, R. J. and Cazenave, A.: Sea-level rise and its impact on coastal zones, *Science*, 328, 1517–1520, 2010.
- Nicholls, R. J., Hanson, S., Herweijer, C., Patmore, N., Hallegatte, S., Corfee-Morlot, J., Chateau, J., and Muir-Wood, R.: Ranking port cities with high exposure and vulnerability to climate extremes exposure estimates, *Environment Working Papers No. 1*, OECD, 2008.
- NPCC: Climate change adaptation in New York City: Building a risk management response, *Ann. N. Y. Acad. Sci.*, Special Issue New York City Panel on Climate Change, 1196, 356, 2010.
- NYC-DCP: New York City population projections by Age/Sex & Borough 2030 briefing booklet, New York City Department of City Planning, New York, 2006.
- NYC-DCP: Vision 2020: New York City Comprehensive Waterfront Plan, New York City Department of City Planning, New York, 2011.
- Pielke Jr, R. A., Gratz, J., Landsea, Ch., W., Collins, D., Saunders, M. A., and Musulin, R.: Normalized hurricane damages in the United States: 1900–2005, *Nat. Hazards Rev.*, 9, 29–42, 2008.
- Rosenzweig, C., Solecki, W., Hammer, S. A., and Mehrotra, S.: Cities lead the way in climate-change action, *Nature*, 467, 909–911, 2010.
- Sussman, E. and Major, D.: Chapter 5: Law and regulation, *Ann. N. Y. Acad. Sci.*, Special Issue New York City Panel on Climate Change, 1196, 87–112, 2010.
- USACE: Metro New York Hurricane Transportation Study, Interim Technical Data Report, US Army Corps of Engineers (USACE), FEMA, New York, 1995.